Consumption of soft drinks and health-related quality of life in the adult population

Running title: **Soft drinks and quality of life**

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Abstract

Background/Objectives: Despite the accumulated evidence on the health risks associated with sugar-sweetened beverages, the industry has funded mass communication strategies promoting the idea that soft drinks, including sugar-sweetened beverages, may represent a source of wellbeing. This study assessed the association between consumption of soft drinks and health-related quality of life (HRQL), as a proxy of wellbeing, in the adult population of Spain.

Methods: The cohort was established in 2008-10 with 8,417 individuals representative of the Spanish population aged 18-60 years. Habitual soft drink consumption was assessed with a validated diet history at baseline. HRQL was measured using the SF-12 questionnaire at baseline and in a subsample of 2,132 study participants in 2012. The analyses were performed using linear regression and adjusted for the main confounders.

Results: In cross-sectional analyses at baseline, those who drank ≥1 serving/day of SSB had a lower (worse) score on the physical composite summary (PCS) of the SF-12 (adjusted linear regression coefficient: -1.08; 95% CI: -1.60 to -0.54) than those who drank <1 serving/week. Results were similar among individuals younger than 35 years (-1.06; 95% CI: -1.79 to -0.32), those who were not dieting (-1.21; 95% CI: -1.80 to -0.62), those who did not lose >5 kg in the previous 4 years (-0.79; 95% CI: -1.87 to 0.29), and in those without morbidity (-1.18; 95% CI: -1.91 to -0.46). Neither SSB nor artificially sweetened beverages (ASB) showed an association with the mental composite summary (MCS) of the SF-12. In the prospective analyses, no association was observed between baseline consumption of SSB or ASB and the changes in the PCS and MCS score from 2008-2010 to 2012.

Conclusions: No evidence was found that soft drink consumption has a beneficial effect on either the physical or mental dimensions of HRQL.

Keywords

Diet; Beverages; Carbonated beverages; Quality of life; Personal satisfaction.

INTRODUCTION

The consumption of sugar-sweetened beverages (SSB) has increased steeply during the last decades. For instance, from 1950 to 2000 the per capita consumption of SBB showed a fivefold increase in the US[1] and an even larger increase in Spain.[2] Although the consumption seems to have leveled-off in recent years,[3,4] SSB remains one of the main sources of added sugars in the diet of populations in Western countries.[5,6]

There is substantial evidence from well-designed prospective studies that SSB augment the long-term risk of several cardiometabolic disorders, including obesity, metabolic syndrome, diabetes mellitus and cardiovascular disease.[7,8] There is also emerging evidence of an association between SSB and certain cancers.[9,10] These effects mainly derive from the intake of fructose, which is used to sweeten these beverages.[11] Similar results might also apply to sacarose, which is the main sweetener of soft-drinks in Europe. Lastly, several clinical trials have shown that reduction of SSB consumption leads to meaningful weight loss.[8] Therefore, based on its caloric and nutrient contents and related health benefits and risks, drinking water has been ranked as the preferred beverage to fulfill daily water needs, while SSB have been ranked in the lowest position.[12,13] On the other hand, artificially sweetened beverages (ASB) might be an acceptable alternative to SSB because they do not include fructose and they provide few to no calories; however, their long-term health consequences are uncertain.[8]

It has been suggested that, through the sale and promotion of unhealthy commodities like SSB, transnational corporations are major drivers of global epidemics of non-communicable diseases.[14] In fact, despite the accumulated evidence on the health risks associated with SSB, the beverage industry has funded mass communication strategies promoting the idea that all types of drinks, including SSB, may represent a good choice for hydration: "*all non-alcoholic beverages, and some weak alcoholic beverages hydrate and contribute to adequate*

hydration".[15] Furthermore, the beverage industry has frequently funded TV commercials linking soft-drink consumption to playing sports as well as enjoying music, friendship and freedom and, therefore, has implicitly promoted an association with wellbeing. Other campaigns have more explicit. For instance the main producer of SSB has claimed that an association exists between choosing a particular brand name and wellbeing: *"Open an ice cold [brand name] and choose happiness"*[16] and another large producer has recently launched an important marketing campaign in China entitled "*Bring happiness home*"[17]. To our knowledge, however, no scientific study has yet tested whether this association is true.

One proxy for wellbeing, as regards health status, is health-related quality of life (HRQL), which represents the individual perception of wellbeing in several spheres of life, including physical and mental aspects and their implications to social function. Specifically, the physical sphere refers to physical functioning, role limitations due to physical health, bodily pain and general health, while the mental sphere corresponds to role limitations due to emotional problems, vitality and mental health. Thus, this paper has examined for the first time the association between soft drinks and HRQL in the general adult population. Our hypothesis, formulated before inspection of the data, was that soft drink consumption shows no association with any of the dimensions of HRQL.

METHODS

Study design and participants

Data have been taken from the ENRICA study whose methods have been reported elsewhere.[18] Briefly, this is a cross-sectional study conducted from 2008-10 among 12,948 individuals representative of the Spanish population aged 18 years and older. Information on socio-demographic variables, several lifestyles, HRQL and morbidity was collected through a phone interview. In two subsequent home visits, the research staff obtained dietary information including consumption of soft drinks, conducted a physical exam and obtained blood samples. We have restricted this analysis to the 9,460 persons aged 18-60 years, because consumption of soft drinks is very low in older adults in Spain.

In 2012 we conducted a new phone interview and a home visit in a subsample of 2,261 participants to update information on lifestyles other than diet, HRQL and morbidity.

Study participants gave informed written consent. Both the cross-sectional study and the follow-up study were approved by the Ethics Research Committee of "La Paz" University Hospital in Madrid.

Study variables

Soft drinks

Consumption of food and beverages during the last year was estimated with a computerized diet history developed from that used in the EPIC-Spain cohort study.[19,20] We recorded consumption of the following beverages: carbonated SSB, including caffeinated colas, caffeine-free colas, and different types of non-cola sodas; non-carbonated SSB, like fruit punches, lemonades or other fruit drinks; and ASB (diet or light soft drinks). We used sets of photographs to help in estimating the serving size. One standard serving of soft drinks was deemed to contain 200 ml.

Health-related quality of life

HRQL was assessed with the SF-12 health questionnaire, which has been validated in Spain.[21,22] The 12 items of this questionnaire assess 8 health dimensions, which can be summarized by two global HRQL indicators: the physical component summary (PCS) and the mental component summary (MCS). The PCS and MCS scores are standardized to a national norm with a mean of 50 and a standard deviation of 10; this allows comparison of the scores for each study participant against the mean score in the Spanish population. A higher score in PCS or MCS indicates a higher HRQL.

Potential confounders of the study association

We also collected data on variables which might be associated with both soft drink consumption and HRQL. Specifically, we asked about socio-demographic characteristics (age, sex, level of education, cohabitation), tobacco smoking and self-reported sleeping time. As regards diet, we considered total energy intake, coffee consumption, and adherence to the Mediterranean diet, as summarized by the Trichopoulou index,[23] excluding the item on alcohol intake which was considered separately. We also asked participants whether they had been following a diet to lose weight during the last year and whether they had lost weight in the last 4 years. Physical activity at leisure time was estimated with the EPIC-Spain questionnaire,[24] and was expressed as metabolic equivalents (MET) per week.

Weight and height were measured with standardized procedures;[25] body mass index (BMI) was calculated as weight in kg divided by squared height in m. Obesity was defined as BMI $\geq$30 kg/m^2. Lastly, we collected data on morbidity. Hypertension was defined as systolic blood pressure $\geq$140 mmHg, diastolic blood pressure $\geq$90 mm Hg, or being under hypertensive treatment; hypercholesterolemia as serum total cholesterol of $\geq$200 mg/dl or receiving lipid lowering treatment; and diabetes mellitus as fasting serum glucose 126 mg/dl

or treatment with oral antidiabetic drugs or insulin.[26] We also obtained self-reported data on the following physician-diagnosed diseases: cardiovascular disease, cancer at any site, asthma or chronic bronchitis, sleep apnea, peptic ulcer, cholelithiasis, cirrhosis, osteoarthritis, hip fracture, eye cataract and periodontal disease.

Statistical analysis

Cross-sectional analysis

From the 9,460 participants aged 18-60-years, we excluded 60 with missing information on the SF-12 questionnaire, 706 who lacked data on diet, and 277 without data on other study variables. As a result, the analyses were conducted with 8,417 individuals.

The association between consumption of soft drinks and the PCS or MCS on the SF-12 was summarized by unstandardized regression coefficients and their 95% confidence interval (CI) obtained from linear models. Consumption of soft drinks was classified into three *a priori*-defined categories (<1 serving/week, which served as reference, 1-6 servings/week, and ≥1 serving/day), which were modeled with dummy terms; analyses were repeated using tertiles of soft drink consumption. We tested for a linear dose-response relationship by modeling soft drink intake as a continuous variable. We also ran separate analyses for carbonated and non-carbonated SSB and for ASB. Additionally, we performed the same analysis specifically for caffeinated soft drinks (either sugar- or artificially-sweetened), because caffeine has biological effects which may be related to HRQL. As an ancillary analysis to assess the robustness of the main results, we used logistic models to estimate odds ratios (OR) for suboptimal HRQL (< median versus ≥median of PCS or MCS score in the study sample) according to soft drink intake. All models were adjusted for the confounders listed above. Since obesity, hypertension, hypercholesterolemia and diabetes may act as mediators of the

study association rather than confounders, we repeated the analyses without adjustment for these three variables.

Lastly, we performed several sensitivity analyses. We limited the analyses to individuals younger than 35 years, because they show the highest consumption of soft drinks and are more likely to keep stable dietary habits than older subjects, who may change diet because of increasing health consciousness and the diagnosis of health disorders. We also restricted the analyses to subjects who did not follow a diet to lose weight or did not lose substantial weight (>5 kg) over the preceding 4 years, because dieting and weight loss could motivate participants to change from SSB to ASB, and also affect HRQL.[27] Finally, because of the substantial influence of morbidity on HRQL, we ran the analyses only among individuals without morbidity (obesity, hypertension, hypercholesterolemia, diabetes and self-reported diseases).

Longitudinal analysis

Among the 2,261 individuals followed up to 2012, 2,132 provided complete information on the study variables at baseline and at the end of follow-up. We ran linear regression models where the dependent variable was the change in the PCS or MCS score between the end of follow-up and baseline (a negative value represents a worsening in HRQL), and the main independent variables were the categories of SSB consumption at baseline. We also used multinomial logistic regression to estimate OR for improved and worsened HRQL versus no change in HRQL, according to soft drink intake. We defined a clinically relevant improvement in HRQL as a 3-point increase in the PCS or MCS score; conversely, a 3-point decrease as a worsening, and a change <3 points as no change in HRQL.[21,22] Linear and logistic models were adjusted for the same confounders as in the cross-sectional analyses and also for the baseline scores on the PCS or MCS -- as appropriate -- and for changes in lifestyle

and self-reported morbidity during the follow-up. Sensitivity analyses were as commented above.

In both the cross-sectional and the longitudinal analyses, we tested whether the study association varied with sex, by using interaction terms defined as the product of sex by categories of soft drink consumption; the models with and without interaction terms were compared using the likelihood ratio test. Given that we found no sex interactions, results are presented for the total study participants.

The analyses were performed with the STATA software (version 11.0; Stata Corp., College Station).

RESULTS

At baseline, mean (SD) consumption of soft drinks was 155.7 (279.6) ml/day; of this amount, 129.6 (247.3) ml/day corresponded to SSB and 26.1 (26.2) ml/day to ASB. As regards SSB, 55.6% of participants drank <1/serving/week, 21.6% consumed 1-6 servings/week, and 22.8% ≥1 serving/day. Corresponding figures for ASB were 91.6%, 4.7%, and 3.7%.

Compared with individuals who consumed <1 serving/week of SSB, those who drank ≥1 servings/day were more frequently men, with lower education, higher energy intake, lower adherence to the Mediterranean diet, and less coffee but higher alcohol intake; they also showed a higher BMI, higher percentage of smokers and more frequent morbidity. In contrast, the highest consumers of ASB were less frequently men, had a slightly higher adherence to the Mediterranean diet, and lower coffee consumption but higher alcohol intake; moreover, they were more likely to be on a diet, to have lost >5 kg in the last 4 years and to suffer from diabetes mellitus (**Table 1**).

Table 2 shows the age-adjusted mean of the PCS and the MCS of the SF-12 according to soft drink consumption. In general, the higher the consumption of SSB and ASB, the lower (worse) was the score on the PCS; no association, however, was found between drinking SSB or ASB and the score on the MCS.

After adjustment for all confounders, those who drank ≥1 serving/day of SSB had a lower score on the PCS (regression coefficient [RC]: -1.08; 95% CI: -1.60 to -0.54) than those who drank <1 serving/week (**Table 3**). Results in the same direction were found for carbonated and non-carbonated SSB separately (**Table 3**). Results for total SSB were also similar among individuals who were younger than 35 years (RC: -1.06; 95% CI: -1.79 to -0.32), those who were not dieting (RC: -1.21; 95% CI: -1.80 to -0.62), those who did not lose >5 kg in the previous 4 years (RC: -0.79; 95% CI: -1.87 to 0.29), and in those without morbidity (RC: -

1.18; 95% CI: -1.91 to -0.46). In addition, in multivariate logistic regression models, the OR of having a PCS score below the sample median was 1.21 (95% CI: 1.05 to 1.40) for those who consumed ≥1 serving/day of SSB versus <1 serving/week. However, neither SSB nor ASB showed an association with the MCS on the SF-12 (**Table 3**). Finally, those consuming ≥1 serving/day of caffeinated soft drinks (including SSB and ASB) showed lower PCS score (RC: -0.79; 95% CI: -1.41 to -0.16).

Results were similar when the analyses were repeated using the tertile distribution of soft drink consumption, and in analyses without adjustment for obesity, hypertension, hypercholesterolemia and diabetes, which may be mediators of the study association (data not shown).

Longitudinal analysis

During 4 years of follow-up, the mean (SD) change in the PCS score was -0.25 (9.1), and in the MCS was 0.07 (11.9). However, 31.9% of study participants showed a clinically relevant improvement in the PCS, while 31% experienced a worsening; corresponding figures for the MCS were 38% and 34.3%.

No association was observed between baseline consumption of SSB or ASB and the changes in the PCS and MCS scores from 2008-2010 to 2012 (**Table 4**). Results were similar when analyses were limited to individuals who were younger than 35 years, with no dieting, who did not lose >5 kg in the last 4 years, or who were without morbidity (results not shown). Lastly, compared to individuals who consumed <1serving/week of SSB, those who drank ≥1 serving/day had an OR= 1.15 (95% CI: 0.84 to 1.57) for improved PCS score and an OR= 1.06 (95% CI: 0.78 to 1.45) for worsened PCS; the corresponding OR (95% CI) for improvement and worsening in MCS was, respectively, 1.03 (0.76 to 1.40) and 1.05 (0.77 to 1.43).

DISCUSSION

In this study among the adult population of Spain, the consumption of SSB was cross-sectionally associated with a worse score on the physical dimension of HRQL. However, in the longitudinal analyses we found no association between soft drink consumption and HRQL. In any case, no beneficial effect of SSB or ASB on HRQL was observed.

In Spain, as we found in the present study, the mean consumption of soft drinks is close to 150 ml/day. Moreover, about 1 out of 4 adult individuals drinks 1 or more servings daily, with an average intake around 500 ml/day. These figures are lower than in several American countries, which ranked as the top consumers in the world. For instance, in 2009 the mean intake of soft drinks was 465 ml/day in the US and 400 ml/day in Mexico.[28] Notwithstanding this, mean consumption in our study was similar to that reported by participants in large US prospective studies showing the excess cardiometabolic risk associated with SSB. In these studies mean intake ranged from 85 to 165 ml/day.[27,29,30]

As in previous population-based studies, consumption of SSB was more frequent among those with lower education and was a marker of an unhealthy lifestyle.[27,31-33] Drinking SSB was associated with tobacco smoking, a worse quality diet and higher energy intake. Given that individuals who drank ≥1 serving/day of SSB showed an energy intake almost 400 kcal/day higher than those who drank <1 serving/week, about half of this excess energy intake is explained by SSB *per se* and the other half by other diet components. It is known that fructose used as sweetener does not stimulate important signals for appetite regulation, including insulin or leptin,[11] thus excess energy intake from soft drinks may not be compensated with a subsequent reduction on the consumption of other products. Furthermore, soft drinks are frequently associated with the consumption of energy-rich and unhealthy foods.[34] Also of note is that because of the higher consumption of SSB among the less educated and in those with higher BMI and with diabetes, SSB may well be contributing to

the inverse educational gradient of obesity and diabetes in many countries.[25,35] In contrast, consumption of ASB showed no association with unhealthy lifestyles. Given that higher consumers of ASB were more likely to be on a diet, a lack of association with higher energy intake was to be expected.

In cross-sectional analysis we found a consistent association between consumption of all types of SSB and a worse score on the PCS score of the SF-12. The size of the association was small, and statistical significance may be partly due to the large sample used in this study. However, the magnitude of the association was comparable to that found between several chronic diseases and HRQL. For instance, in the IQOLA project conducted among the general population of eight countries, allergies or hypertension were associated with a 1 to 1.5-point reduction in the PCS.[36] Also, in asthmatic patients, anxiety and depression were linked to a 1.2-point lower PCS, which was considered clinically relevant.[37] Moreover, although small in absolute terms, the size of the association is similar to that observed in programs to promote healthy lifestyles (e.g., physical activity in the workplace) or tele-healthcare interventions for chronic patients, since these only lead to small improvements in HRQL (about 1.5 points in either the PCS or the MCS on the SF-12),[38,39].

In our study, the mean scores of the physical dimension of HRQL were somewhat higher than the expected population mean (i.e. 50 points) in all categories of soft drinks consumption. This may due to restricting the analyses to young individuals, whose physical quality of life is usually better than in older subjects. This may affect generalization of results but it is not likely to bias the findings on the study association. In this sense, we think our results provide some clues as to possible mechanisms of the study association. Specifically, in cross-sectional analyses ASB were not linked to a poorer score on the PCS. This suggests that the inverse association between SSB and the physical dimension of HRQL could be related to the high fructose or sacarose content in SSB.[11,40]

In longitudinal analyses, no association was found between soft drinks and HRQL. One possible explanation is that the relatively short follow-up did not allow sufficient time for changes in weight and other metabolic disorders to be reflected as worse HRQL. At the end of follow-up, those consuming ≥1 serving/day of SSB weighed only 1.1 kg more than those drinking <1 serving/week, after adjustment for basal weight and other confounders. Although there is evidence that obesity and weight gain lead to worse HRQL, particularly in the physical dimensions,[41] the weight difference observed in our study is not enough to substantially affect HRQL. It could also be argued that the effect of soft drinks on HRQL may be context-sensitive, and that the null association observed in this study reflects a mixture of different contexts. For instance, soft drinks may be associated with better HRQL when consumed with friends at the beach during holidays (as portrayed in several Spanish TV ads), while they may be linked to worse HRQL when drunk alone to stay awake in order to work at night. In our view, the effect of beverages should be distinguished from the effect of the drinking context; in fact, any type of beverage, including water, may be associated with wellbeing when consumed in the appropriate context. Although we did not collect information on drinking context, we did attempt to examine the study association among groups of individuals with a health status usually linked to wellbeing: subjects who were not dieting, did not lose substantial weight in the recent past, and were free of severe morbidity. Again, none of them showed an association between drinking SSB and HRQL.

A main strength of this study was that the sample was representative of the adult population of Spain; in fact, the consumption of soft drinks in this study was almost identical to that reported in Government-funded population-based studies in Spain.[42] Another strength was that the study included a wide variety of soft drinks.

However, this study also had some limitations. First, dietary intake, including soft drinks, was measured with some error. When the soft drink intake obtained with the diet history used is

this study is compared against the mean of seven 24-hour recalls during one year, the Pearson correlation was 0.40, which indicates moderate agreement[20]. Moreover, the most likely effect of this error is to bias effect estimates towards the null. Second, we assessed soft drink consumption only at baseline, and we assumed that consumption was stable over follow-up. Nevertheless, results were similar when the analyses were limited to those younger than 35 years, in whom consumption is presumed to be relatively stable. In any case, we were not able to investigate the effect of changes in soft drink intake on HRQL. This information would have been directly relevant to guide health counseling on soft drink consumption, particularly SSB. Third, HRQL may not fully capture the concept of wellbeing. However, it is a reasonable proxy, because it is unlikely that someone would have a high level of wellbeing in the context of poor HRQL; in fact, SF-12 scores are positively associated with wellbeing.[43,44] Lastly, although the analyses were adjusted for many potential confounders, there is still a possibility of some unmeasured or residual confounding.

In conclusion, we found no evidence of a beneficial effect of soft drink consumption on either the physical or mental dimensions of HRQL. Thus, our results do not support the claim of the beverage industry of an association between soft drink intake and wellbeing.[16] Given the accumulated evidence on the cardiometabolic disorders associated with SSB, and the fact that marketing strategies (particularly through TV and social networks) have a substantial effect on consumption patterns,[45] there is growing pressure to set limits on marketing strategies for SSB.[46,47] While these limits are progressively enforced,[48] the first step is to ensure that health claims regarding soft drinks do not overstate their potential benefits, including wellbeing.

CONFLICT OF INTEREST

None of the authors has a conflict of interest

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AUTHOR CONTRIBUTIONS

AL, ELG and FRA conceived the study and drafted the manuscript. AL analyzed data. All authors contributed to data interpretation and reviewed the manuscript for important intellectual content. All authors read and approved the final manuscript.

REFERENCES

1. Duffey KJ, Popkin BM. Shifts in patterns and consumption of beverages between 1965 and 2002. *Obesity (Silver Spring)* 2007; **15**: 2739-2747.
2. Varela G, Ávila JM, Cuadrado C, del Pozo S, Ruiz E, Moreiras O. Consumo de alimentos. In: Valoración de la dieta española de acuerdo al panel de consumo alimentario. Madrid: Fundación Española de la Nutrición. Madrid: Ministerio de Medio Ambiente y Medio Rural y Marino, 2008.
3. Welsh JA, Sharma AJ, Grellinger L, Vos MB. Consumption of added sugars is decreasing in the United States. *Am J Clin Nutr* 2011; **94**: 726-734.
4. Campos R, Gómez-Bengoechea G. Las Bebidas refrescantes y su impacto socioeconómico en España. Madrid: IESE Bussines School; 2012.
5. Marriott BP, Olsho L, Hadden L, Connor P. Intake of added sugars and selected nutrients in the United States, National Health and Nutrition Examination Survey (NHANES) 2003–2006. *Crit Rev Food Sci Nutr* 2010; **50**: 228-258.
6. Guallar-Castillón P, Muñoz-Pareja M, Aguilera MT, León-Muñoz LM, Rodríguez-Artalejo F.Food sources of sodium, saturated fat and added sugar in the Spanish hypertensive and diabetic population. *Atherosclerosis* 2013; **229**: 198-205.
7. Richelsen B. Sugar-sweetened beverages and cardio-metabolic disease risks. *Curr Opin Clin Nutr Metab Care* 2013; **16**: 478-484.
8. Hu FB. Resolved: there is sufficient scientific evidence that decreasing sugar-sweetened beverage consumption will reduce the prevalence of obesity and obesity-related diseases. *Obes Rev* 2013; **14**: 606-619.
9. Drake I, Sonestedt E, Gullberg B, Ahlgren G, Bjartell A, Wallström P, Wirfält E. Dietary intakes of carbohydrates in relation to prostate cancer risk: a prospective study in the Malmö Diet and Cancer cohort. *Am J Clin Nutr* 2012; **96**: 1409-1418.
10. Schernhammer ES, Bertrand KA, Birmann BM, Sampson L, Willett WC, Feskanich D. Consumption of artificial sweetener- and sugar-containing soda and risk of lymphoma and leukemia in men and women. *Am J Clin Nutr* 2012; **96**: 1419-1428.
11. Stanhope KL, Schwarz JM, Havel PJ. Adverse metabolic effects of dietary fructose: results from the recent epidemiological, clinical, and mechanistic studies. *Curr Opin Lipidol* 2013; **24**: 198-206.
12. Popkin BM, Armstrong LE, Bray GM, Caballero B, Frei B, Willett WC. A new proposed guidance system for beverage consumption in the United States. *Am J Clin Nutr* 2006; **83**: 529-542.
13. Harvard School of Public Health. The Nutrition source. Healthy drinks.http://www.hsph.harvard.edu/nutritionsource/healthy-drinks/ (accessed October 18; 2014).
14. Moodie R, Stuckler D, Monteiro C, Sheron N, Neal B, Thamarangsi T, Lincoln P, Casswell S, Lancet NCD Action Group. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. *Lancet* 2013; **381**: 670-679.

15. European Hydration Institute. Educational materials. Hydration card. Hydration card about variety. http://www.europeanhydrationinstitute.org/wp-content/uploads/2012/08/EHI_Hydration_Card_Variety.pdf (accessed October 19; 2014).

16. The Coca-Cola Company. Open Happiness. What is happiness? http://www.coca-cola.com/happiness/ (accessed October 22; 2014).

17. PepsiCo. PepsiCo Launches "Happy Spring Festival · Bring Happiness Home" 2015 Campaign. http://www.pepsico.com/live (accessed February 02; 2015).

18. Rodríguez-Artalejo F, Graciani A, Guallar-Castillón P, León-Muñoz LM, Zuluaga MC, López-García E, Gutiérrez-Fisac JL, Taboada JM, Aguilera MT, Regidor E, Villar-Álvarez F, Banegas JR. Rationale and methods of the study on nutrition and cardiovascular risk in Spain (ENRICA). *Rev Esp Cardiol* 2011; **64**: 876-882.

19. EPIC group of Spain. Relative validity and reproducibility of a diet history questionnaire in Spain. I. Foods. EPIC Group of Spain. European Prospective Investigation into Cancer and Nutrition. *Int J Epidemiol* 1997; Suppl **1**: S91-S99.

20. Guallar-Castillón P, Sagardui-Villamor J, Balboa-Castillo T, Sala-Vila A, Ariza Astolfi MJ, Sarrión Pelous MD, León-Muñoz LM, Graciani A, Laclaustra M, Benito C, Banegas JR, Artalejo FR. Validity and reproducibility of a Spanish dietary history. *PLoS One* 2014; **9**: e86074.

21. Vilagut G, Valderas JM, Ferrer M, Garin O, López-García E, Alonso J. Interpretation of SF-36 and SF-12 questionnaires in Spain: physical and mental components. *Med Clin (Barc)* 2008; **130**: 726-735.

22. Schmidt S, Vilagut G, Garin O, Cunillera O, Tresserras R, Brugulat P, Mompart A, Medina A, Ferrer M, Alonso J. Reference guidelines for the 12-Item Short-Form Health Survey version 2 based on the Catalan general population. *Med Clin (Barc)* 2012; **139**: 613-625.

23. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. *N Engl J Med* 2003; **348**: 2599-2608.

24. Pols MA, Peeters PH, Ocké MC, Slimani N, Bueno-de-Mesquita HB, Collette HJ. Estimation of reproducibility and relative validity of the questions included in the EPIC Physical Activity Questionnaire. *Int J Epidemiol* 1997; 26: Suppl **1**: S181-S189.

25. Gutiérrez-Fisac JL, Guallar-Castillón P, León-Muñoz LM, Graciani A, Banegas JR, Rodríguez-Artalejo F. Prevalence of general and abdominal obesity in the adult population of Spain, 2008-2010: the ENRICA study. *Obes Rev* 2012; **13**: 388-392.

26. Graciani A, León-Muñoz LM, Guallar-Castillón P, Rodríguez-Artalejo F, Banegas JR. Cardiovascular health in a southern Mediterranean European country: a nationwide population-based study. *Circ Cardiovasc Qual Outcomes* 2013; **6**: 90-98.

27. de Koning L, Malik VS, Kellogg MD, Rimm EB, Willett WC, Hu FB. Sweetened beverage consumption, incident coronary heart disease, and biomarkers of risk in men. *Circulation* 2012; **125**: 1735-1741.

28. Euromonitor International. Who Drinks What: Identifying International Drinks Consumption Trends. 2nd Ed. London: Euromonitor International; 2011.

29. Pan A, Malik VS, Hao T, Willett WC, Mozaffarian D, Hu FB. Changes in water and beverage intake and long-term weight changes: results from three prospective cohort studies. *Int J Obes (Lond)* 2013; **37**: 1378-1385

30. Qi Q, Chu AY, Kang JH, Jensen MK, Curhan GC, Pasquale LR, Ridker PM, Hunter DJ, Willett WC, Rimm EB, Chasman DI, Hu FB, Qi L. Sugar-sweetened beverages and genetic risk of obesity. *N Engl J Med* 2012; **367**: 1387-1396.

31. Han E, Powell LM. Consumption patterns of sugar-sweetened beverages in the United States. *J Acad Nutr Diet* 2013; **113**: 43-53.

32. InterAct consortium. Consumption of sweet beverages and type 2 diabetes incidence in European adults: results from EPIC-Inter Act. *Diabetologia* 2013; **56**: 1520-1530.

33. Mullie P, Aerenhouts D, Clarys P. Demographic, socioeconomic and nutritional determinants of daily versus non-daily sugar-sweetened and artificially sweetened beverage consumption. *Eur J Clin Nutr* 2012; **66**: 150-155.

34. Kant AK, Graubard BI, Mattes RD. Association of food form with self-reported 24-h energy intake and meal patterns in US adults: NHANES 2003-2008. *Am J Clin Nutr* 2012; **96**: 1369-1378.

35. McLaren L. Socioeconomic status and obesity. *Epidemiol Rev* 2007; **29**: 29-48.

36. Alonso J, Ferrer M, Gandek B, Ware JE Jr, Aaronson NK, Mosconi P, Rasmussen NK, Bullinger M, Fukuhara S, Kaasa S, Leplège A; IQOLA Project Group, Health-related quality of life associated with chronic conditions in eight countries: results from the International Quality of Life Assessment (IQOLA) Project. *Qual Life Res* 2004; **13**: 283-298.

37. Kullowatz A, Kanniess F, Dahme B, Magnussen H, Ritz T. Association of depression and anxiety with health care use and quality of life in asthma patients. *Respir Med* 2007; **101**: 638-644.

38. Harding J, Freak-Poli R LA, Backholer K, Peeters A. Change in health-related quality of life amongst participants in a 4-month pedometer-based workplace health program. *J Phys Act Health* 2013; **10**: 533-543.

39. Cartwright M, Hirani SP, Rixon L, Beynon M, Doll H, Bower P, Bardsley M, Steventon A, Knapp M, Henderson C, Rogers A, Sanders C, Fitzpatrick R, Barlow J, Newman SP; Whole Systems Demonstrator Evaluation Team.Effect of telehealth on quality of life and psychological outcomes over 12 months (Whole Systems Demonstrator telehealth questionnaire study): nested study of patient reported outcomes in a pragmatic, cluster randomised controlled trial. *BMJ* 2013; **346**: f653.

40. Rezvani R, Cianflone K, McGahan JP, Berglund L, Bremer AA, Keim NL, Griffen SC, Havel PJ, Stanhope KL. Effects of sugar-sweetened beverages on plasma acylation stimulating protein, leptin, and adiponectin: relationships with metabolic outcomes. *Obesity (Silver Spring)* 2013; **21**: 2471-2480.

41. León-Muñoz LM, Guallar-Castillón P, Banegas JR, Gutiérrez-Fisac JL, López-García E, Jiménez FJ, Rodríguez-Artalejo F.Changes in body weight and health-related quality-of-life in theolderadultpopulation. *Int J Obes (Lond)* 2005; **29**: 1385-1391.

42. Ministerio de Agricultura, Alimentación y Medio Ambiente: Consumo alimentario en España mes a mes Año 2001 a 2013http://www.magrama.gob.es/es/alimentacion/temas/consumo-y-comercializacion-y-distribucion-alimentaria/panel-de-consumo-alimentario/ultimos-datos/ (accessed October 24; 2014).

43. Centers forDisease Control and Prevention:Health-RelatedQuality of Life (HRQL). Well-beingconcepts. http://www.cdc.gov/hrqol/wellbeing.htm (accessed October 24; 2014).

44. World Health Organization. Regional Office for Europe: Joint meeting of experts on targets and indicators for health and well-being in Health 2020.http://www.euro.who.int/en/what-we-publish/abstracts/joint-meeting-of-experts-on-targets-and-indicators-for-health-and-well-being-in-health-2020 (accessed October 25; 2014).

45. Zimmerman FJ, Bell JF. Associations of television content type and obesity in children. *Am J Public Health* 2010; **100**: 334-340.

46. Swinburn B, Sacks G, Lobstein T,Rigby N, Baur LA, Brownell KD, Gill T, Seidell J, Kumanyika S; International Obesity Taskforce Working Group on Marketing to Children.The 'Sydney Principles' for reducing the commercial promotion of foods and beverages to children. *Public Health Nutr* 2008; **11**: 881-886.

47. World Health Organization. Marketing of foods high in fat, salt and sugar to children: update 2012–2013. Copenhagen: WHO Regional Office for Europe, 2013.

48. Romero-Fernández MM, Royo-Bordonada MA, Rodríguez-Artalejo F. Evaluation of food and beverage television advertising during children's viewing time in Spain using the UK nutrient profile model. *Public Health Nutr* 2013; **16**: 1314-132.

Table 1. Age-adjusted baseline characteristics of the study participants, according to categories of soft drink consumption. N=8,417.

	Total sugar-sweetened beverages			Artificially sweetened beverages		
	<1 serving/week	1-6 servings/week	≥1 serving/day	<1 serving/week	1-6 servings/week	≥1 serving/day
Participants, n (%)	4681 (55.6)	1819 (21.6)	1917 (22.8)	8448 (91.6)	410 (4.7)	320 (3.7)
Beverage intake, ml/d	4.2 (48)	105 (64)	459 (407)	0.1 (3)	109 (57)	560 (538)
Gender, male, %	47	51	59	52	35	43
Education, primary or less, %	18.2	18.5	24.5	19.6	17.2	16.8
Current smoker, %	31.9	30.9	38.3	33.4	26.9	36.2
Sleep, h/d	7.3 (1.4)	7.3 (1.7)	7.2 (1.8)	7.3 (1.8)	7.2 (1.6)	7.2 (1.8)
Living alone, %	4.0	4.1	4.3	4.1	3.8	5.0
Energy intake, kcal/d	2112 (769)	2351 (768)	2508 (862)	2250 (947)	2334 (814)	2246 (707)
Coffee consumption, ml/d	83 (103)	78 (98)	71 (101)	79 (101)	82 (79)	82 (95)
Mediterranean diet score[a]	3.8 (0.7)	3.7 (3.4)	3.4 (3.3)	3.7 (1.8)	3.8 (2.0)	3.8 (1.8)
Alcohol intake, g/d	7.4 (20.5)	9.0 (17.1)	10.2 (21.9)	8.5 (18.4)	7.9 (14.2)	5.9 (12.5)
Current dieting	20.8	23.3	19.3	19.9	34.3	32.2
Recent weight loss[b]	25.7	22.6	25.9	24.0	33.9	40.4
Physical activity, METs h/wk[c]	30.7 (27.4)	31.7 (34.1)	30.7 (30.6)	31.1 (36.8)	28.7 (30.4)	29.3 (30.4)
BMI, kg/m^2	26.0 (5.5)	26.2 (4.3)	26.7 (4.4)	26.1 (6.4)	26.9 (6.1)	27.4 (5.4)
Hypertension, %	19.8	19.5	23.7	20.5	15.3	25.0
Diabetes, %	2.4	3.3	3.2	2.5	5.2	4.2
Hypercholesterolemia, %	43.7	42.3	42.2	43.3	41.8	42.8
At least one self-reported disease[d], %	30.9	27.6	33.0	30.7	27.0	32.9

For continuous variables mean and standard deviation (SD) are reported.

[a]According to Trichopoulou et al. (excluding alcohol consumption).

[b]Losing>5 kg at least once in the last 4 years before the baseline interview.

[c]Leissure physical activity measured in metabolic equivalent tasks h/week.

[d]Including: cardiovascular disease, cancer, asthma or chronic bronchitis, sleep apnea, peptic ulcer, cholelithiasis, cirrhosis, osteoarthritis, hip fracture, eye cataract, and periodontal disease.

Table 2. Age-adjusted mean (95% CI) of the physical composite summary (PCS) and mental composite summary (MCS) scores of the SF-12, according to the baseline consumption of soft drinks.

	<1 serving/week	1-6 servings/week	≥1 serving/day	P for trenda
TSSB				
Participants, n	4681	1819	1917	
PCS	52.5 (52.2-52.7)	52.4 (52.0-52.8)	51.1 (50.7-51.6)	0.001
MCS	49.5 (49.1-49.8)	49.5 (49.0-50.1)	49.4 (48.9-49.9)	0.11
CSSB				
Participants, n	5732	1512	1173	
PCS	52.3 (52.1-52.6)	52.3 (51.9-52.8)	50.9 (50.3-51.5)	0.002
MCS	49.5 (49.2-49.8)	49.6 (49.0-50.1)	49.3 (48.6-50.0)	0.19
N-CSSB				
Participants, n	6648	1038	731	
PCS	52.2 (52.0-52.5)	52.2 (51.7-52.8)	51.2 (50.5-51.9)	0.02
MCS	49.5 (49.2-49.8)	49.2 (48.5-49.9)	49.2 (48.4-50.0)	0.25
ASB				
Participants, n	7706	397	314	
PCS	52.2 (52.0-52.4)	52.2 (51.4-53.0)	51.1 (49.9-52.2)	0.04
MCS	49.5 (49.2-49.8)	49.1 (48.0-50.2)	49.1 (47.8-50.3)	0.71

TSSB: total sugar-sweetened beverages; CSSB: carbonated sugar-sweetened beverages; N-CSSB: non-carbonated sugar-sweetened beverages; ASB: artificially sweetened beverages

[a]P value from the regression models in which soft-drink consumption was included as a continuous variable.

Table 3. Cross-sectional association between baseline consumption of soft drinks and the physical composite summary (PCS) and mental composite summary (MCS) scores of the SF-12[a]

	<1 serving/week	1-6 servings/week	≥1 serving/day	P for trend[b]
TSSB				
Participants, n	4681	1819	1917	
PCS	Ref.	-0.37 (-0.84 to 0.09)	-1.08 (-1.60 to -0.54)	0.08
MCS	Ref.	-0.18 (-0.75 to 039)	0.00 (-0.59 to 0.59)	0.43
CSSB				
Participants, n	5732	1512	1173	
PCS	Ref.	-0.21 (-0.71 to 0.29)	-0.89 (-1.53 to -0.25)	0.15
MCS	Ref.	-0.11 (-0.72 to 0.49)	0.04 (-0.68 to 0.77)	0.77
N-CSSB				
Participants, n	6648	1038	731	
PCS	Ref.	-0.25 (-0.80 to 0.29)	-0.89 (-1.62 to -0.16)	0.02
MCS	Ref.	-0.46 (-1.17 to 0.25)	-0.20 (-1.01 to 0.61)	0.38
ASB				
Participants, n	7706	397	314	
PCS	Ref.	0.09 (-0.75 to 0.92)	-0.41 (-1.47 to 0.66)	0.18
MCS	Ref.	-0.29 (-1.41 to 0.82)	0.05 (-1.11 to 1.22)	0.85

Values are beta coefficients (95% CI). TSSB: total sugar-sweetened beverages; CSSB: carbonated sugar-sweetened beverages; N-CSSB: non-carbonated sugar-sweetened beverages; ASB: artificially sweetened beverages.

[a]Linear regression models adjusted for age (years), sex, educational level (primary, secondary or university), current smoker, sleep (quintiles of hours/day), living alone, energy intake (quintiles of kcal/day), coffee consumption (quintiles of ml/day), Mediterranean diet score (quintiles), alcohol consumption (abstainer, moderate or heavy drinker), current dieting, weight loss of >5 kg in the last 4 years, leisure physical activity (quintiles of METs h/week), BMI (<25, 25-29.9 or ≥30), hypertension, diabetes, hypercholesterolemia, and self-reported disease (cardiovascular disease, cancer, asthma or chronic bronchitis, sleep apnea, peptic ulcer, cholelithiasis, cirrhosis, osteoarthritis, hip fracture, eye cataract, and periodontal disease).

[b]P value from the regression models in which soft-drink consumption was included as a continuous variable.

Table 4. Prospective association of changes in the physical composite summary (PCS) and mental composite summary (MCS) scores of the SF-12 from 2008 to 2012 with baseline categories of soft drink consumption.[a]

	<1 serving/week	1-6 serving/week	≥1 serving/day	P for trend[b]
TSSB				
Participants, n	1243	423	466	
PCS change	-0.17 (-0.63 to 0.30)	-0.56 (-1.35 to 0.22)	-0.20 (-0.98 to 0.57)	0.77
MCS change	-0.11 (-0.72 to 0.50)	0.67 (-0.35 to 1.70)	-0.01 (-1.03 to 1.01)	0.56
CSSB				
Participants, n	1459	377	296	
PCS change	-0.03 (-0.45 to 0.40)	-0.83 (-1.66 to 0.01)	-0.64 (-1.61 to 0.33)	0.86
MCS change	-0.02 (-0.57 to 0.54)	-0.03 (-1.12 to 1.07)	0.59 (-0.68 to 1.87)	0.69
N-CSSB				
Participants, n	1729	237	166	
PCS change	-0.30 (-0.68 to 0.08)	0.09 (-0.96 to 1.13)	-0.23 (-1.49 to 1.01)	0.24
MCS change	0.04 (-0.46 to 0.54)	0.68 (-0.69 to 2.05)	-0.51 (-2.15 to 1.13)	0.94
ASB				
Participants, n	1990	75	67	
PCS change	-0.23 (-0.58 to 0.13)	-0.64(-2.49 to 1.21)	-0.57 (-2.52 to 1.38)	0.48
MCS change	0.08 (-0.38 to 0.55)	-0.29 (-2.71 to 2.14)	-0.04 (-2.60 to 2.62)	0.21

Values are beta coefficients (95% CI). TSSB: total sugar-sweetened beverages; CSSB: carbonated sugar-sweetened beverages; N-CSSB: non-carbonated sugar-sweetened beverages; ASB: artificially sweetened beverages.

[a]Linear regression models adjusted for the same variables as in Table 3, and for baseline SF-12 score (quintiles) and for changes in lifestyle factors during follow-up: smoking (no change, began, quit), physical activity (quintiles of METs h/week in 2012) and alcohol consumption (no change, increased or decreased the category of consumption) and incident self-reported disease.

[b]P for trend was determined using soft-drinks consumption as a continuous variable in the regression model.